Saccadic eye movement

Reflexive eye movements, also known as saccades, are rapid, involuntary movements of the eyes that allow us to quickly shift our gaze from one point to another. These movements are essential for visual perception, as they enable us to scan our environment efficiently and gather visual information. Saccades are generated by the coordinated action of various brain regions, including the frontal eye fields, superior colliculus, and brainstem nuclei.

There are two main types of saccades:

Voluntary Saccades: These are under conscious control and are typically used to explore the visual scene or to track moving objects voluntarily.

Reflexive Saccades: Also known as “prosaccades,” or Optokinetic nystagmus these are automatic responses to sudden changes in the visual field. Reflexive saccades occur rapidly and are triggered by external stimuli, such as the appearance of a new object or a sudden movement.

Reflexive saccades play a crucial role in orienting our attention towards relevant visual stimuli in our environment. They are believed to be mediated by a subcortical pathway involving the superior colliculus, which receives input from the retina and relays information to the brainstem nuclei responsible for generating eye movements. This subcortical pathway allows for quick, automatic responses to visual stimuli, even before the visual information reaches higher cortical areas involved in conscious perception and decision-making.

In summary, reflexive eye movements, or saccades, are rapid, involuntary shifts of gaze that help us quickly orient towards important visual stimuli in our environment. They are essential for visual perception and are mediated by a subcortical pathway that allows for fast, automatic responses to changes in the visual field.

Our eyes are in continuous motion. Even when we attempt to fix our gaze, we produce so called “fixational eye movements”, which include microsaccades, drift, and ocular microtremor (OMT). Microsaccades, the largest and fastest type of fixational eye movement, shift the retinal image from several dozen to several hundred photoreceptors and have equivalent physical characteristics to saccades, only on a smaller scale (Martinez-Conde, Otero-Millan & Macknik, 2013). OMT occurs simultaneously with drift and is the smallest of the fixational eye movements (~1 photoreceptor width, >0.5 arcmin), with dominant frequencies ranging from 70 Hz to 103 Hz (Martinez-Conde, Macknik & Hubel, 2004). Due to OMT's small amplitude and high frequency, the most accurate and stringent way to record it is the piezoelectric transduction method. Thus, OMT studies are far rarer than those focusing on microsaccades or drift. Here we conducted simultaneous recordings of OMT and microsaccades with a piezoelectric device and a commercial infrared video tracking system. We set out to determine whether OMT could help to restore perceptually faded targets during attempted fixation, and we also wondered whether the piezoelectric sensor could affect the characteristics of microsaccades. Our results showed that microsaccades, but not OMT, counteracted perceptual fading. We moreover found that the piezoelectric sensor affected microsaccades in a complex way, and that the oculomotor system adjusted to the stress brought on by the sensor by adjusting the magnitudes of microsaccades [1)].

The study of eye movements, in particular saccades, is increasingly used as a model for higher order networks. Besides testing motor control, it can also give insight into neurodegenerative processes and cognitive function [2) 3) 4) 5)].

Infrared oculography is a non-invasive and accurate method of recording eye movements [6)], and has entered clinical practice in expertise centers. Due to the extensive networks involved in the control of eye movements, both focal and more widespread neuronal processes can be investigated using this infrared oculography [7) 8) 9)].

Transsaccadic memory is the neural process that allows humans to perceive their surroundings as a seamless, unified image despite rapid changes in fixation points. The human eyes move rapidly and repeatedly, focusing on a single point for only a short period of time before moving to the next point. These rapid eye movements are called saccades.

A saccade is a quick, simultaneous movement of both eyes between two or more phases of fixation in the same direction.

In contrast, in smooth pursuit movements, the eyes move smoothly instead of in jumps. The phenomenon can be associated with a shift in frequency of an emitted signal or a movement of a body part or device.

Controlled cortically by the frontal eye fields (FEF), or subcortically by the superior colliculus, saccades serve as a mechanism for fixation, rapid eye movement, and the fast phase of optokinetic nystagmus.

The word appears to have been coined in the 1880s by French ophthalmologist Émile Javal, who used a mirror on one side of a page to observe eye movement in silent reading, and found that it involves a succession of discontinuous individual movements.

The medial longitudinal fasciculus carries information about the direction that the eyes should move.

It connects the cranial nerve nuclei III (Oculomotor nerve), IV (Trochlear nerve) and VI (Abducens nerve) together, and integrates movements directed by the gaze centers (frontal eye field) and information about head movement (from cranial nerve VIII, Vestibulocochlear nerve). It is an integral component of saccadic eye movements as well as vestibulo-ocular and optokinetic reflexes.

Quantitative saccadic testing is a non-invasive method of evaluating the neural networks involved in the control of eye movements. The aim of a study of Nij Bijvank et al., from the Neuro-ophthalmology Expertise Center, Amsterdam and Moorfields Eye Hospital and The National Hospital for Neurology and Neurosurgery, London, is to provide a standardized and reproducible protocol for infrared oculography measurements of eye movements and analysis, which can be applied for various diseases in a multicenter setting.

Development of a protocol to Demonstrate Eye Movement Networks with Saccades (DEMoNS) using infrared oculography. Automated analysis methods were used to calculate parameters describing the characteristics of the saccadic eye movements. The two measurements of the subjects were compared with descriptive and reproducibility statistics.

Infrared oculography measurements of all subjects were performed using the DEMoNS protocol and various saccadic parameters were calculated automatically from 28 subjects. Saccadic parameters such as: peak velocity, latency and saccade pair ratios showed excellent reproducibility (intra-class correlation coefficients > 0.9). Parameters describing performance of more complex tasks showed moderate to good reproducibility (intra-class correlation coefficients 0.63-0.78).

This study provides a standardized and transparent protocol for measuring and analyzing saccadic eye movements in a multicenter setting. The DEMoNS protocol details outcome measures for treatment trial which are of excellent reproducibility. The DEMoNS protocol can be applied to the study of saccadic eye movements in various neurodegenerative and motor diseases [10].

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